Effect of job rotation on need for recovery, musculoskeletal complaints, and sick leave due to musculoskeletal complaints: a prospective study among refuse collectors

Kuijer, P.P.F.M.; van der Beek, A.J.; van Dieen, J.H.; Visser, B.; Frings-Dresen, M.H.W.

published in
American Journal of Industrial Medicine
2005

DOI (link to publisher)
10.1002/ajim.20159

document version
Publisher's PDF, also known as Version of record

AMERICAN JOURNAL OF INDUSTRIAL MEDICINE 47:394–402 (2005)

Effect of Job Rotation on Need For Recovery, Musculoskeletal Complaints, and Sick Leave Due to Musculoskeletal Complaints: A Prospective Study Among Refuse Collectors

P. Paul F.M. Kuijer, PhD,[1,2]* Allard J. van der Beek, PhD,[3,4] Jaap H. van Dieën, PhD,[2] Bart Visser, PhD,[2] and Monique H.W. Frings-Dresen, PhD[1]

Background *Job rotation might be an effective preventive measure to reduce the prevalence of musculoskeletal complaints, although its effect has not been yet established. The aim of the present study is to evaluate the effect of job rotation in refuse collecting on need for recovery, prevalence of musculoskeletal complaints, and sick leave due to musculoskeletal complaints.*

Methods *A 1-year prospective study among refuse collectors was performed, using standardized questionnaires. Job rotation was performed between collecting two-wheeled containers and driving a refuse truck. The experimental groups of rotating refuse collectors at t_0 and t_1 (group R-R) and non-rotating refuse collectors at t_0 and rotating refuse collectors at t_1 (group NR-R) were compared with a reference group of non-rotating refuse collectors at t_0 and t_1 (group NR-NR).*

Results *The adjusted need for recovery of group R-R was marginally significantly lower than need for recovery of the reference group. Groups R-R and NR-R had a more than two times higher risk for complaints of the low back than the reference group. No other significant results were found.*

Conclusions *Job rotation seemed to coincide with a reduced need for recovery and was associated with an increased risk of low back complaints. No effects were found on sick leave due to musculoskeletal complaints. The results might be influenced by the healthy worker selection effect in the reference group and its inverse in the rotating groups.* Am. J. Ind. Med. 47:394–402, 2005. © *2005 Wiley-Liss, Inc.*

KEY WORDS: job rotation; prevention; interventions; recovery; musculoskeletal complaints; low back pain; sickness absence; occupational epidemiology; refuse collecting

[1]Coronel Institute for Occupational and Environmental Health, AmCOGG Amsterdam Center for Research into Health and Health Care, Academic Medical Center/University of Amsterdam, The Netherlands

[2]Institute for Fundamental and Clinical Movement Sciences, Faculty of Human Movement Sciences, Vrije Universiteit Amsterdam, The Netherlands

[3]Department of Public and Occupational Health, Institute for Research in Extramural Medicine, VU University Medical Center, Amsterdam, The Netherlands[4]Department of Public Health, Erasmus Universiteit Rotterdam, The Netherlands.

Contract grant sponsor: Dutch Health Research & Development Council/Medical Sciences (ZonMw); Contract grant number: 97110120,8 SK/VB.

*Correspondence to: P. Paul F.M. Kuijer, Coronel Institute for Occupational and Environmental Health, Academic Medical Center/University of Amsterdam, P.O. box 22700, 1100 DE Amsterdam, The Netherlands. E-mail: p.p.kuijer@amc.uva.nl

Accepted 7 February 2005

DOI 10.1002/ajim.20159. Published online in Wiley InterScience (www.interscience.wiley.com)

INTRODUCTION

Refuse collectors around the world are at a high risk for the development of musculoskeletal complaints. Poulsen et al. [1995] reported a nearly two times higher incidence rate of musculosketelal complaints for refuse collectors in Denmark than for the total Danish workforce. Verbeek [1991] found that the incidence rate of disability for work among refuse collectors in the capital of the Netherlands was about four times higher than the rate among office workers of the same refuse collecting company. A similar comparison was made by Yang et al. [2001] for refuse collectors in Taiwan. The risks for musculoskeletal complaints of the low back and elbow/wrist among refuse collectors were more than two times higher than those of their colleagues that worked in the office. Two studies on occupational accidents among refuse collectors in Brazil also stressed the high risk for musculoskeletal complaints due to the high physical workload [Pimenta Velloso et al., 1997; Robazzi et al., 1997]. In the United States of America, musculoskeletal injuries make up about 80% of all workers' compensation claims among refuse collectors [Dorevitch and Marder, 2001]. Strains and sprains accounted for 44.5% of these claims. About the same results were found in a study performed among municipal refuse collectors in the state of Florida [An et al., 1999]. A similar study performed in the capital of Denmark reported that ''overloading of the body'' was the third most important reason for occupational injury (18% of the cases) [Ivens et al., 1998]. These studies stress the importance of the introduction of preventive measures to reduce the risk of musculoskeletal disorders in refuse collecting [Kuijer and Frings-Dresen, 2004].

The high physical workload in refuse collecting is seen as an important risk factor for these musculoskeletal complaints and disorders [Kemper et al., 1990; Luttmann et al., 1992; De Looze et al., 1995; Poulsen et al., 1995; Frings-Dresen et al., 1995a; Schibye et al., 2001a; Kuijer et al., 2003]. Therefore, interventions should be aimed at reducing the physical workload by a reduction in physical work demands. In many countries, domestic refuse is collected by a team of a driver and one or more collectors [Luttmann et al., 1992; Frings-Dresen et al., 1995a; Poulsen et al., 1995; Robazzi et al., 1997]. The efficacy of job rotation in refuse collecting has already been demonstrated. Two previously performed studies showed that job rotation resulted in a reduction of the physical work demands and physical workload of refuse collectors working with polythene bags and two-wheeled containers [Kuijer et al., 1999; Kuijer et al., 2004]. Kuijer et al. [1999] described job rotation between street sweeping, collecting polythene bags, and driving a cleaning machine while Kuijer et al. [2004] described job rotation between collecting two-wheeled containers and driving a refuse truck. However, in both studies the question remains whether the established reduction in physical work demands and work load of the refuse collectors outweighs the possible negative long term health effect of the increase in work demands and physical workload in the less strenuous job of driving of the cleaning machine and the refuse truck, respectively. Therefore, the effects of job rotation on musculoskeletal complaints and sick leave due to these complaints should be established.

To the authors' knowledge, no studies were performed that actually evaluated the effect of job rotation on the occurrence of musculoskeletal complaints. Only one study reported possible health effects. In a study on the design of check-out systems, Hinnen et al. [1992] found that job rotation had a beneficial impact on the prevalence of musculoskeletal disorders in cashier work with scanners. This study indicates that job rotation might indeed be an effective measure to reduce the prevalence of musculoskeletal complaints.

Besides the prevalence of musculoskeletal complaints and sick leave due to these complaints, need for recovery was also assessed in the present study. Insufficient recovery is seen as an important intermediate variable in the onset of complaints [Kilbom, 1988; Sluiter et al., 2000]. It is hypothesized that repeated insufficient recovery may start a vicious cycle, in which extra effort has to be exerted at the beginning of every new working period to prevent performance breakdown. Eventually, this ongoing process may lead to health complaints. Need for recovery appeared to be a predictor of experienced health complaints among coach drivers [Sluiter et al., 1999], and of job turnover in a study among truck drivers [De Croon et al., 2004].

Therefore, the aim of this study was to evaluate the effect of job rotation between refuse collecting and truck driving on the need for recovery, the 12-month prevalence of musculoskeletal complaints and sick leave due to musculoskeletal complaints.

MATERIALS AND METHODS

Design and Study Population

A 1-year prospective study among male refuse collectors working with two-wheeled containers was initiated in 1998. Two measurements were performed: at baseline (t_0) and after 1 year of follow-up (t_1). To evaluate the effect of job rotation, two groups were initially formed. The first group consisted of employees who worked as non-rotating refuse collectors at t_0 and t_1 (group NR-NR). The second group consisted of employees who rotated between refuse collecting and truck driving at t_0 and t_1 (group R-R). During the present study, an intermediate group was formed. This group consisted of employees who were non-rotating refuse collectors at t_0 and rotated between refuse collecting and truck driving at t_1 (group NR-R). Job rotation was performed during the day and between days [Kuijer et al., 2004].

Information on the addresses of 24 companies employing these three groups, was derived from:

- A mailing to all the members of the Association for Waste and Cleaning Management (NVRD) and the Association of Dutch Waste Management Companies (VNA);
- An advertisement in the periodical of the NVRD;
- An appeal during a lecture held at the annual conference of the NVRD;
- A telephone call to key members of the NVRD and VNA;
- Ad-hoc contacts with management and employees from refuse collecting organizations.

All employees were requested to complete a questionnaire at t_0 and t_1. The questionnaires were filled in at the office of the refuse collecting organization. In deliberation with the management, the employees filled in the questionnaires at the beginning or at the end of the working day. This was mostly done in a group session. A researcher was present to explain the purpose of the study and to answer any questions concerning the questionnaire. The researchers involved were blinded to group membership: it was not known whether participating refuse collectors rotated or not. A possibility existed to fill in the questionnaire with the help of the researcher. In this way, also employees with less fluency in reading and/or writing could participate. When an employee was not present, his manager was asked to hand over the questionnaire (including a post-paid envelope) to the employee. After filling it in, the employee could return the questionnaire to his manager or send it directly to the researchers.

One contacted company did not want to participate in the study, in view of an ongoing reorganization. Therefore, the first questionnaire was presented to 280 employees working in 23 different companies. At t_0, 243 (87%) questionnaires were completed by 121 non-rotating participants and 122 rotating participants. At t_1, three companies were no longer willing to participate in the study (21 participants). Twenty-five participants were no longer employed by the company. Of the remaining 197 participants, 130 (66%) returned the follow-up questionnaire. Of these 130 participants, 46 belonged to group NR-NR, 63 to group R-R, and 21 to group NR-R.

Assessment of Independent Variables

At t_0 and t_1, the participants were requested to complete a questionnaire concerning personal characteristics (age, body height, body weight, the number of working years at the company) and work demands (number of hours collecting per week, number of hours driving per week, number of working hours per week, number of working days per week).

Assessment of Dependent Variables

Need for recovery, musculoskeletal complaints, and sick leave due to musculosketelal complaints were also individually assessed using the questionnaire at t_0 and t_1. The need for recovery was assessed using the 11-items dichotomous scale as developed by Van Veldhoven and Meijman [1994]. An example of an item is ''After a working day I am often too tired to start other activities (Yes/No)'' [Sluiter et al., 1999]. A total need for recovery was calculated for each employee. The scores on the 11-items (1-0) were summed up and transformed into a percentage of the maximum score, ranging from 0 to 100.

To assess the 12-month prevalence of low back, neck, shoulder, hand/wrist, and knee complaints a Dutch translation of the Standardized Nordic Questionnaire [Kuorinka et al., 1987] was used. Sick leave due to musculoskeletal complaints was assessed using one item [Burdorf et al., 1996]. This item assessed whether or not the participant had reported sick due to musculoskeletal complaints in the last 12 months. The need for recovery at t_1, the 12-month prevalence of musculoskeletal complaints at t_1, and the 12-month prevalence of sick leave at t_1 were used as dependent variables in separate analyses.

Analyses and Statistics

First, mean and standard deviation of the personal characteristics (age, body height, body weight and number of working years at the company) and work demands at t_0 (number of collecting hours per week, number of driving hours per week, number of working days per week) of the three groups were calculated. Besides, the mean and standard deviation of the number of collecting hours per week and number of driving hours per week were calculated at t_1 to establish the effect of job rotation. Differences between groups were tested using analysis of variance.

Second, a non-response analysis was performed. The non-respondents at t_1 were compared with the respondents at t_1, classified according to the three groups and using the data obtained at t_0. Differences with respect to the personal characteristics, musculoskeletal complaints, and sick leave due to musculoskeletal complaints were tested using a *t*-test and a Mann–Whitney U test for parametric and non-parametric values, respectively.

Third, mean need for recovery, 12-month prevalence of the musculoskeletal complaints, and 12-month prevalence of sick leave due to musculoskeletal complaints at t_0 and t_1 were calculated for the three groups. Next, crude mean difference scores (DSs) and corresponding 95% confidence intervals (CIs) were calculated for the need for recovery using analyses of variance. Crude prevalence rate ratios (PRs) and corresponding 95% CIs were calculated for the 12-month prevalence of low back, neck, shoulder, hand/wrist, and knee

complaints and 12-month prevalence of sick leave due to musculoskeletal complaints using Cox's proportional hazards regression analysis with a constant risk period. Cox's proportional hazards regression analysis was performed, because the prevalence of (sick leave due to) musculoskeletal complaints was relatively high. For both variables (DS and PR), the groups NR-R and R-R were compared with the reference group NR-NR.

Finally, the effect of job rotation on the need for recovery was controlled for possible confounding due to age at t_0, number of working hours per week at t_0, and number of working years in the company at t_0 (adjusted mean DS). The effect of job rotation on (sick leave due to) musculoskeletal complaints was controlled for potential confounding due to age at t_0, (sick leave due to) musculoskeletal complaints at t_0, number of working hours per week at t_0, and number of working years in the company at t_0.

Job rotation may also have an effect on several intermediate physical and psychosocial risk factors, such as the time driving or decision authority. Therefore, these variables were a priori not taken into account as potential confounders on need for recovery and (sick leave due to) musculoskeletal complaints.

Each of the independent variables was screened separately for confounding. If the DS or PR of group NR-R or R-R changed more than 10%, the variable was labeled as a confounder and included in the multivariate model.

All statistical analyses were performed with version 8.0 of the SPSS statistical package and a significance level of 5% was used.

RESULTS

Group Characteristics

Group NR-R was the youngest of the three groups with a mean age of 29 years (Table I). The other two groups did not significantly differ in age. No significant differences between the three groups were found for the mean values of body height, body weight, and number of years working at the company.

The number of hours collecting and driving differed substantially, as could be expected, due to the effect of job rotation. The mean number of hours collecting per week at t_0 was 34, 31, and 15, for group NR-NR, NR-R, and R-R, respectively. At t_1 the number of hours collecting for group NR-R had changed to 18. The number of hours collecting per week did not change between t_0 and t_1 for groups NR-NR and R-R. The same effect was found for the number of hours driving at t_0 and t_1. At t_0 the number of hours driving per week for the three groups was 1, 1, and 18, respectively. Due to the introduction of job rotation, the number of hours driving per week at t_1 was 19 for the group NR-R. Again, the number of hours driving per week for the groups NR-NR and R-R did not change between t_0 and t_1. The three groups did not differ on the number of working hours per week and the number of working days per week, on average 41 and 5, respectively.

The mean need for recovery of the three groups did not change between t_0 and t_1 (Table II). The 12-month prevalences at t_0 and t_1 for complaints of the low back were higher than for any other part of the body in all three groups.

TABLE I. Mean and Standard Deviation (SD) of the Personal Characteristics and the Work Demands for the Non-rotating (NR-NR) and Rotating (NR-R and R-R) Dutch Refuse Collectors at t_0*

	Group NR-NR		**Group NR-R**		**Group R-R**	
	n = 46		**n = 21**		**n = 63**	
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**
Age (years) at t_0	34	9	**29**$^{\#}$	6	37	9
Body height (m) at t_0	1.80	0.09	1.84	0.06	1.81	0.08
Body weight (kg) at t_0	79	13	78	14	86	12
Working years at company at t_0	8	7	5	5	9	8
Collecting hours per week at t_0	34	8	31	7	**15**$^{\#}$	5
Collecting hours per week at t_1	**31**$^{\#\#}$	15	18	12	15	10
Driving hours per week at t_0	1	3	1	5	**18**$^{\#\#}$	9
Driving hours per week at t_1	**3**$^{\#}$	5	19	13	20	12
Working hours per week at t_0	43	5	41	7	41	7
Working days per week at t_0	5	0	5	1	5	0

NR-NR, non-rotating refuse collectors at t_0 and t_1; NR-R, non-rotating refuse collectors at t_0 and rotating at t_1; R-R, rotating refuse collectors at t_0 and t_1.

*The number of hours of collecting and driving at t_1 is presented for the three groups. Significant results are in bold type ($P < 0.05$; $^{\#}$ lower than the other two groups; $^{\#\#}$ higher than the other two groups).

TABLE II. The Mean Need for Recovery, the 12-Month Prevalence at t_0 and t_1 for Complaints of the Low Back, Neck, Shoulder, Hand/Wrist and Knees and the 12-Month Prevalence for Sick Leave due to Musculoskeletal Complaints for the Non-rotating (NR-NR) and Rotating (NR-R and R-R); Dutch Refuse Collectors

	Group NR-NR		Group NR-R		Group R-R	
	n = 46		n = 21		n = 63	
	t_0	t_1	t_0	t_1	t_0	t_1
Need for recovery (%)	26.8	24.8	23.9	23.9	15.2	14.0
12-month prevalence (%)						
Low back	33	23	30	52	38	48
Neck	9	2	14	14	16	21
Shoulder	9	19	19	24	25	24
Hand/wrist	13	12	14	14	8	5
Knee	20	14	19	15	16	19
Sick leave	52	32	52	38	33	32

NR-NR, non-rotating refuse collectors at t_0 and t_1; NR-R, non-rotating refuse collectors at t_0 and rotating at t_1; R-R, rotating refuse collectors at t_0 and t_1.

For group NR-NR, the prevalence of low back complaints decreased between t_0 and t_1 by 10%. For the other groups R-R and NR-R, this prevalence increased by 10% and 22%, respectively. In addition, high 12-month prevalences were found for complaints of shoulders and knees. For all three groups, the 12-month prevalence of sick leave due to musculoskeletal complaints decreased between t_0 and t_1 by 20%, 14%, and 1%, respectively.

Non-Response Analysis

The non-respondents of group NR-NR had a lower 12-month prevalence of hand/wrist complaints than their responding counterparts. The non-respondents and respondents of this group did not significantly differ on the personal characteristics, work demands, and the other dependent variables. The non-respondents and respondents of group R-R only differed with respect to the number of years working at the company. The respondents worked on average 3 years longer at the company. The non-respondents and respondents of group NR-R did not significantly differ on any of the personal characteristics, work demands, and dependent variables.

Need for Recovery

The crude need for recovery of group R-R was significantly lower than the need for recovery of the reference group (Tables II and IIII). The adjusted need for recovery of group R-R was marginally significantly lower than that of the reference group (P value = 0.052). The crude and adjusted need for recovery of group NR-R did not significantly differ from the reference group.

(Sick Leave due to) Musculoskeletal Complaints

For group R-R a crude PR significantly higher than 1 was found for low back and neck complaints (Table IV). For group NR-R no significant crude PRs were found. The crude PRs for the other body regions of the group R-R were not significant. The crude PRs of the groups R-R and NR-R for sick leave due to musculoskeletal complaints were not significant.

When adjusted for confounding, for group R-R a significant PR of 2.3 was found for complaints of the low back. For group NR-R a significant PR of 2.5 was found for complaints of the low back. The adjusted PRs for the other body regions of the groups R-R and NR-R were not significant. The adjusted PRs for sick leave due to musculoskeletal complaints of the groups R-R and NR-R were also not significant.

TABLE III. Mean Difference Score (DS), Crude and Adjusted for Confounders, and 95% Confidence Interval (CI) of Need for Recovery at t_1 for the Non-rotating (NR-NR, Reference Group) and Rotating (NR-R and R-R); Dutch Refuse Collectors*

	Group NR-NR	Group NR-R		Group R-R	
	n = 46	n = 21		n = 63	
	DS	DS	95% CI	DS	95% CI
Crude DS (%)	0.0	0.9	−11.3–13.0	**10.8**	1.8–19.8
Adjusted DS (%)	0.0	0.5	−11.9–12.9	9.1	−0.1–18.3

A positive DS represents a lower need for recovery than the reference group (and vice versa).
NR-NR, non-rotating refuse collectors at t_0 and t_1; NR-R, non-rotating refuse collectors at t_0 and rotating at t_1; R-R, rotating refuse collectors at t_0 and t_1.
*Significant results are in bold type ($P < 0.05$).

TABLE IV. Prevalence Rate Ratio (PR), Crude and Adjusted for Confounders, and 95% Confidence Interval (CI) for Musculoskeletal Complaints and Sick Leave due to Musculoskeletal Complaints for the Non-rotating (NR-NR, Reference Group) and Rotating (NR-R and R-R); Dutch Refuse Collectors*

	Group NR-NR	Group R-R		Group R-R	
	n = 46	n = 21		n = 63	
	PR	PR	95% CI	PR	95% CI
Crude PRs					
Low back	1.0	2.3	0.9–5.0	**2.1**	1.0–4.3
Neck	1.0	6.1	0.6–59.1	**8.9**	1.2–67.8
Shoulder	1.0	1.3	0.4–3.9	1.3	0.5–3.0
Hand/wrist	1.0	1.2	0.3–5.1	0.4	0.1–1.7
Knee	1.0	1.1	0.3–4.4	1.4	0.5–3.7
Sick leave	1.0	1.2	0.5–2.9	1.0	0.5–2.0
Adjusted PRs					
Low back	1.0	**2.5**	1.0–6.1	**2.3**	1.1–4.9
Neck	1.0	4.6	0.5–44.6	7.5	0.9–57.5
Shoulder	1.0	0.9	0.3–2.8	0.7	0.3–1.9
Hand/wrist	1.0	1.1	0.3–4.5	0.4	0.1–1.8
Knee	1.0	1.1	0.3–4.4	1.7	0.6–4.8
Sick leave	1.0	1.1	0.4–2.6	1.1	0.5–2.3

NR-NR, non-rotating refuse collectors at t_0 and t_1; NR-R, non-rotating refuse collectors at t_0 and rotating at t_1; R-R, rotating refuse collectors at t_0 and t_1.
*Significant results are in bold type ($P < 0.05$).

DISCUSSION

Population and Analyses

The aim of this study was to assess the effect of job rotation between collecting two-wheeled containers and driving a refuse truck on need for recovery and (sick leave due to) musculoskeletal complaints. The questionnaire survey was performed at refuse collecting companies willing to participate. Therefore, these companies may have had a more positive attitude towards work and health issues than companies that did not want to participate. It is expected that this form of selection bias is small, because of the broad search strategy (i.e. five different sources of information) and the withdrawal of only 1 of the 24 companies contacted at t_0. The selection of the population that filled in the first questionnaire may also have been biased. Characteristics of employees who did not respond to the first questionnaire could not be retrieved. At t_1, employees who did not respond were not substantially different from the respondents. The 12-month prevalences of (sick leave due to) musculoskeletal complaints were not associated with losses at t_1, except for the prevalence of hand/wrist complaints in the group NR-NR. Unwillingness to invest effort in the second questionnaire appeared to be the most important reason for non-response at t_1.

In the present study, the physical work demands are self-reported and expressed as for instance the time collecting or driving. Are these self-reported data good estimates of the real exposure? Before the present study was performed, we have quantified the physical work demands of the rotation schemes and non-rotation scheme using a real time based hierarchical task analyses and the physical workload using for instance heart rate, catecholamine excretion, and scales for rated perceived exertion [Kuijer et al., 2004]. The self-reported exposure data in the present study are in line with these previous findings.

Additionally, the physical work demands at the refuse collecting companies are quite similar. First of all, only refuse collectors who collected two-wheeled containers were included. Therefore, refuse collectors of bags or four-wheeled containers were excluded. Moreover, in The Netherlands there is a job specific regulation on maximum production limits for collecting refuse [Frings-Dresen et al., 1995b]. Nor the maximum amount of refuse, nor the maximum number of two-wheeled containers, nor the maximum number of hours collecting, may be exceeded during an 8-hr working day. This guideline is enforced by the government. Since the guideline is substantially below former production levels, every company tries to collect the maximum amount of refuse within this guideline. Due to the guideline, a team of drivers and collectors has to record productivity and report this to their management each day. Therefore, the self-reported exposure is in our opinion a good estimate of the real exposure. Finally, whether or not job rotation is performed, is not dependent on the physical work demands. Therefore, differences in work demands that do exist will be randomly assigned to the three groups.

Given the episodic characteristics of musculoskeletal complaints, it was decided not to restrict analyses to employees without complaints at t_0. All employees who had responded at t_0 and t_1 were included, thereby preventing a selection of employees who were less susceptible of developing complaints. Besides, it may be questioned whether musculoskeletal complaints reported by employees without prior complaints at t_0 can be considered new events [Eisen, 1999; Riihimäki, 1999].

Is Job Rotation Effective?

A previous study showed that the introduction of job rotation between collecting two-wheeled containers and driving the refuse truck resulted in a decrease of the physical work demands and physical workload of refuse collecting only [Kuijer et al., 2004]. Therefore, it was expected that the need for recovery and the prevalence of (sick leave due to) musculoskeletal complaints would be lower in the rotating

groups R-R and NR-R compared to non-rotating reference group NR.

Contrary to our expectation, we found that both rotating groups had a more than two times higher risk of low back complaints. Does this imply that job rotation has a negative effect on the prevalence of musculoskeletal complaints, especially of the low back? Two considerations can be given that support this explanation. First, job rotation probably has no effect on the peak mechanical load during collecting and driving but only on the cumulative mechanical load. In a study on a comparison between peak versus cumulative physical workload risk factors for low back pain, Norman et al. [1998] concluded that cumulative and peak back load provide different information on the risk of back complaints. This may be due to different pathological mechanisms. Therefore, when peak load emerges to be a more important predictor for back complaints than cumulative load, job rotation might be less effective than expected [Frazer et al., 2003]. In the case of refuse collecting, several studies provide insight in mean and peak load from a biomechanical perspective [De Looze et al., 1995; Schibye et al., 2001a; Kuijer et al., 2003]. However, a systematic analysis of their effects in relation to job rotation as performed by Frazer et al. [2003] is outside the scope of this study. Second, truck drivers are exposed to whole body vibration and sit behind the wheel in a relatively static posture. Especially for whole body vibration there is strong evidence that it increases the risk of (low) back complaints [Bernard, 1997; Burdorf and Sorock, 1997; Hoogendoorn et al., 1999]. To a lesser extent this holds true for a static work posture [Burdorf and Sorock, 1997]. Besides, recent evidence suggests that pushing and pulling is not a risk factor for back complaints [Hoozemans et al., 2002]. These two explanations might partly clarify the results of the present study.

Nevertheless, the conclusion that job rotation results in an increased risk of low back complaints appears premature. A major drawback of the design of the present study is its sensitivity to the healthy worker selection effect. The non-rotating reference group may have been relatively healthy and less susceptible to the development of musculoskeletal complaints. This might be caused by either selection at start of employment or drop-out of employees susceptible to complaints in the course of the early years of employment [De Zwart et al., 1997]. The results of three other studies on refuse collectors endorse this healthy worker selection hypothesis. First, Schibye et al. [2001b] found that refuse collectors generally had a higher isometric muscle strength capacity than a control group and concluded that this is an indication of the early selection of young refuse collectors. Second, Lund et al. [2001] assessed the rate at which refuse collectors left their job and identified associated risk factors. They found that out of the more than 1000 refuse collectors in 1994, 30% had left their job in 1997. They concluded that the most prevalent factors affecting selection out of the job were the physical (and psychosocial) work environment factors. Third, the prevalences of low back and especially neck complaints of the reference group in the present study seem surprisingly low compared to the corresponding prevalences in a study among 47 Dutch refuse collectors of two-wheeled containers. In that study, the 12-month prevalences of low back and neck complaints were about 32% and 28%, respectively [Stassen et al., 1993]. In the present study, the prevalences at t_1 of the reference group were 23% and 2%, respectively. Both studies used the same questionnaire. Remarkably, the prevalences of shoulder, hand/wrist, and knee complaints were quite similar in the study of Stassen et al. [1993] and the present study: 18% versus 19%, 12% versus 12%, and 14% versus 14%, respectively. On the whole, the healthy worker selection effect due to complaints of back and neck also seems a plausible reason for explaining the results of the present study. Moreover, the opposite may be true for the rotating groups. The presence of, for instance, low back complaints might have contributed to the decision for a new employee or a refuse collector to become a rotating truck driver. This ''unhealthy'' worker selection effect may be present in our study.

Unfortunately, this study remains inconclusive as to whether job rotation between collecting two-wheeled containers and truck driving is an ineffective measure. However, the results on sick leave due to musculoskeletal complaints and need for recovery may speak in favor of job rotation. First, despite the differences in prevalence of low back complaints, there was no difference in sick leave due to musculoskeletal complaints between the rotating groups and the reference group. Under the assumption that an ''unhealthy worker selection'' effect has taken place in the rotating groups, this may indicate that the presence of musculoskeletal complaints is a less impairing factor in the case of rotating between refuse collecting and truck driving than for refuse collecting only. Second, the need for recovery in the reference group is comparable to the general working population in The Netherlands (25.7%, $n = 9791$) [Van Veldhoven, 1997]. The need for recovery in the group R-R seemed lower than in the reference group. In contrast, the need for recovery at t_1 in the group NR-R did not differ from the reference group. No unambiguous explanation can be given for this result. An explanation might be that at t_1 group NR-R had been driving for less than 1 year. Driving can be a demanding mental task, especially on city streets [Zeitlin, 1995]. Not only must a driver focus on the other traffic, but also steer the large truck in often narrow streets in such a way that the refuse collectors have to transport the two-wheeled containers over a small distance only.

Finally, due the episodic nature of musculoskeletal complaints, the relatively short follow-up period as well as the unhealthy worker selection effect, it appeared to be difficult to evaluate the effectiveness of job rotation in real life. The results of the present study suggest that the

effectiveness of job rotation should be further studied among relatively young and newly contracted employees in carefully chosen jobs. Periods with and without complaints, characteristics of complaints and work ability should be registered in the course of the follow-up, while at the same time exposure is monitored.

ACKNOWLEDGMENTS

The authors thank the management and the employees of the participating refuse collecting organizations. The Dutch Health Research & Development Council/Medical Sciences (ZonMw) financially supported this study as apart of their program on the ''Effectiveness of interventions to reduce socio-economic differences in health (SEGV II).'' Jitske Groothausen, Marco Hoozemans, Jorrit Jansen, Marianne Six Dijkstra, Judith Sluiter, and Marlies Witjes are acknowledged for data collection and processing.

REFERENCES

An H, Englehardt J, Fleming L, Bean J. 1999. Occupational health and safety amongst municipal solid waste workers in Florida. Waste Manage Res 17:369–377.

Bernard BP. 1997. Musculoskeletal disorders and workplace factors: A critical review of epidemiological evidence for work-related musculoskeletal disorders of the neck, upper extremity, and low back (report 97-141). Cincinnati: National Institute for Occupational Safety and Health.

Burdorf A, Sorock GS. 1997. Positive and negative evidence of risk factors for back disorders. Scand J Work Environ Health 23:243–256.

Burdorf A, Van der Steenhoven GA, Tromp-Klaren EGM. 1996. A one-year prospective study on back pain among novice golfers. Am J Sports Med 24:659–664.

De Croon EM, Sluiter JK, Blonk RW, Broersen JP, Frings-Dresen MHW. 2004. Stressful work, psychological job strain, and turnover: A 2-year prospective cohort study of truck drivers. J App Psych 89:442–454.

De Looze MP, Stassen ARA, Markslag AMT, Borst MJ, Wooning MM, Toussaint HM. 1995. Mechanical loading on the low back in three methods of refuse collecting. Ergonomics 38:1993–2006.

De Zwart BCH, Broersen JPJ, Van der Beek AJ, Frings-Dresen MHW, Van Dijk FJH. 1997. Selection related to musculoskeletal complaints among employees. Occup Environ Med 54:800–806.

Dorevitch S, Marder D. 2001. Occupational hazards of municipal solid waste workers. Occup Med: State of the Art Reviews 16:125–133.

Eisen EA. 1999. Methodology for analyzing episodic events. Scand J Work Environ Health 25(Suppl. 4):36–42.

Frazer MB, Norman RW, Wells RP, Neumann WP. 2003. The effects of job rotation on the risk of reporting low back pain. Ergonomics 46:904–919.

Frings-Dresen MHW, Kemper HCG, Stassen ARA, Crolla IFAM, Markslag AMT. 1995a. The daily work load of refuse collectors working with three different collecting methods: A field study. Ergonomics 38:2045–2055.

Frings-Dresen MHW, Kemper HCG, Stassen ARA, Markslag AMT, De Looze MP, Toussaint HM. 1995b. Guidelines for energetic load in three methods of refuse collecting. Ergonomics 38:2056–2064.

Hinnen U, Läubli T, Guggenbuhl U, Krueger H. 1992. Design of check-out systems including laser scanners for sitting working postures. Scand J Work Environ Health 18:186–194.

Hoogendoorn WE, Van Poppel MNM, Bongers PM, Koes BW, Bouter LM. 1999. Physical load during work and leisure time as risk factors for back pain. Scand J Work Environ Health 25:387–403.

Hoozemans MJM, Van der Beek AJ, Frings-Dresen MHW, Van der Woude LHV, Van Dijk FJH. 2002. Low-back and shoulder complaints among workers with pushing and pulling tasks. Scand J Work Environ Health 28:293–303.

Ivens UI, Lassen JH, Kaltoft BS, Skov T. 1998. Injuries among domestic waste collectors. Am J Ind Med 33:182–189.

Kemper HCG, Van Aalst R, Leegwater A, Maas S, Knibbe JJ. 1990. The physical and physiological workload of refuse collectors. Ergonomics 33:1471–1486.

Kilbom Å. 1988. Intervention programmes for work-related neck and upper limb disorders: Strategies and evaluation. Ergonomics 31:735–747.

Kuijer PPFM, De Vries WHK, Van der Beek AJ, Van Dieën JH, Visser B, Frings-Dresen MHW. 2004. Effect of job rotation on work demands, physical and mental workload, and recovery of refuse truck drivers and collectors. Hum Factors 46:437–448.

Kuijer PPFM, Hoozemans MJM, Kingma I, De Vries WHK, Veeger HEJ, Van Dieën JH, Van der Beek AJ, Visser B, Frings-Dresen MHW. 2003. Effect of a redesigned two-wheeled container for refuse collecting on mechanical loading of low back and shoulders. Ergonomics 46:543–560.

Kuijer PPFM, Frings-Dresen MHW. 2004. World at work: Refuse collectors. Occup Environ Med 61:282–286.

Kuijer PPFM, Visser B, Kemper HCG. 1999. Job rotation as a factor in reducing physical workload at a refuse collecting department. Ergonomics 42:1167–1178.

Kuorinka IAA, Jonsson B, Kilbom Å, Vinterberg H, Biering-Sorensen F, Andersson GBJ, Jorgensen K. 1987. Standardised Nordic questionnaires for the analysis of musculoskeletal symptoms. Appl Ergon 18:233–237.

Lund T, Iversen L, Poulsen KB. 2001. Work environment factors, health, lifestyle and marital status as predictors of job change and early retirement in physically heavy occupations. Am J Ind Med 40:161–169.

Luttmann A, Laurig W, Jäger M. 1992. Logistical and ergonomic transportation capacity for refuse collection workers: A work physiology field study. Ergonomics 35:1045–1061.

Norman RW, Wells RP, Neumann P, Shannon HS, Kerr M. 1998. A comparison of peak vs. cumulative physical work exposure risk factors for the reporting of low back pain in the automotive industry. Clin Biomech 13:561–573.

Pimenta Velloso M, Moreira dos Santos E, Antonio dos Anjos L. 1997. The labor process and work-related accidents among garbage collectors in Rio de Janeiro, Brazil [Portugese]. Cad Saude Publ 13:693–700.

Poulsen OM, Breum NO, Ebbehoj N, Hansen AM, Ivens UI, Van Lelieveld D, Malmros P, Matthiassen L, Nielsen BH, Nielsen EM, Schibye B, Skov T, Stenbaek EI, Wilkins CK. 1995. Collection of domestic waste. Review of occupational health problems and their possible causes. Sci Total Environ 170:1–19.

Riihimäki H. 1999. Musculoskeletal diseases—A continuing challenge for epidemiologic research. Scand J Work Environ Health 25(Suppl 4):31–35.

Robazzi MLCC, Moriya TM, Favero M, Lavrador MAS, Luis MAV. 1997. Garbage collectors: Occupational accidents and coefficients of frequency and severity per accident. Ann Agric Env Med 4: 91–96.

Schibye B, Søgaard K, Martinsen D, Klausen K. 2001a. Mechanical load on the low back and shoulders during pushing and pulling of two-wheeled waste containers compared with lifting and carrying of bags and bins, Clin Biomech 16:549–559.

Schibye B, Hansen AF, Sogaard K, Christensen H. 2001b. Aerobic power and muscle strength among young and elderly workers with and without physically demanding work tasks. Appl Ergon 32:425–431.

Sluiter JK, Frings-Dresen MHW, Meijman ThF, Van der Beek AJ. 2000. Reactivity and recovery from different types of work measured by catecholamines and cortisol: A systematic literature review. Occup Environ Med 57:298–315.

Sluiter JK, Van der Beek AJ, Frings-Dresen MHW. 1999. The influence of work characteristics on the need for recovery and experienced health: A study on coach drivers. Ergonomics 42:573–583.

Stassen ARA, Markslag AMT, Frings-Dresen MHW, Kemper HCG, De Looze MP, Toussaint HM. 1993. Workload of refuse collectors working at refuse collecting organizations: Conclusions, guidelines and recommendations [Dutch]. Den Haag: SDU Uitgeverij. p 30.

Van Veldhoven M. 1997. Reference values from the Dutch VBBA questionnaire [Dutch]. Amsterdam: SKB Center for expertise on work and health.

Van Veldhoven M, Meijman ThF. 1994. The measurement of psychosocial job demands with a questionnaire (VBBA) [Dutch]. Amsterdam: NIA Dutch institute for working conditions. p 59.

Verbeek JHAM. 1991. Disability due to back and other musculoskeletal complaints (PhD thesis) [Dutch]. Amsterdam: Coronel Institute for Occupational and Environmental Health. p 166.

Yang C-H, Chang W-T, Chuang H-Y, Tsai S-S, Wu T-N, Sung F-C. 2001. Adverse health effects among household waste collectors in Taiwan. Env Res 85:195–199.

Zeitlin LR. 1995. Estimates of driver mental workload: A long-term field trial of two subsidiary tasks. Human Factors 37:611–621.